ADDRESS

Delivered by the President, Professor H. H. Turner, on presenting the Gold Medal of the Society to Professor G. E. Hale.

The Council have awarded the Gold Medal to Professor George E. Hale "for his method of photographing the solar surface and other astronomical work," and it is now my pleasant duty to lay before you the grounds on which this award has been made.

"It cannot be too often repeated," remarks Professor Hale himself in a recent memoir, "that the Sun is the only star whose phenomena can be studied in detail." We all assent at once not only to the proposition itself, but to the obvious corollary that particular attention should be paid to solar phenomena; and yet it would appear from the history of astronomy that the statement, however often repeated, has fallen on deaf ears. If we turn, for instance, to the list of awards of our medal, which, unless the Society has been prejudiced, should reflect in some degree the relative interest taken in the various departments of astronomy, we find a score of recognitions for good work in lunar or planetary theory; another score for planetary and cometary discoveries; more than a score for catalogues of stars and nebulæ; nearly a dozen for the determination of important constants (such as that of aberration); and among awards which are more miscellaneous in character the spectroscopic study of the stars has three times been honoured. The study of the Sun, however, appears in the list but twice, and only once explicitly. In 1857 the medal was awarded to Schwabe "for his discovery of the periodicity of the solar spots," and in 1862 to Warren De la Rue "for his Astronomical researches, and especially for his application of photography," which included, though incidentally merely, the invention of the photo-heliograph. The poverty of this record is striking, and seems to show, unless the Society has failed in its duty to an extent which I am not prepared to admit, that far too little attention has been paid to the Sun hitherto. It is a happy augury for the new century that we desire so early in its course to do honour to one of those who are taking the lead in rectifying the omissions of the past.

May we, before passing to his work, dwell for a few moments on the two awards of half a century ago which I have just

mentioned, those of 1857 and of 1862? They afford a background of some historical interest for the events of to-day and yesterday.

Heinrich Schwabe, a gentleman of Dessau, began to observe the solar spots very zealously with a small telescope in 1826, and continued for seventeen years before he made his modest announcement of periodicity in 1843. The announcement was entirely new and unsuspected. In the Presidential Address, on awarding the medal in 1857, Mr. Manuel Johnson showed how little the discovery had been anticipated by quoting from various eminent writers explicit denials that there was law, or anything regular, in the appearance of Sun-spots. And even when the eleven-year period was announced by Schwabe the subject attracted little attention, until Humboldt reannounced it in 1851 in the third volume of his *Cosmos*. We could scarcely have a more characteristic illustration of the strange, almost obstinate, neglect of the Sun and all concerning him which appears instead of the particular attention we might have expected.

Dawning solar physics was represented by Schwabe alone—a modest, patient, untiring observer. "Twelve years," says Mr. Johnson, "he spent to satisfy himself; six more years to satisfy, and still thirteen more to convince, mankind. For thirty years never has the Sun exhibited his disc above the horizon of Dessau without being confronted by Schwabe's imperturbable telescope, and that appears to have happened on an average about 300 days a year."

And then follows a paragraph on which I need make no comment; it is sufficient to remember that it was spoken to this Society in 1857.

"Let us hope that the example will not be lost. Men are apt to speak of astronomy as an exhausted science, meaning that all that can be known is known. No doubt, being the most perfect, it is in one sense the most exhausted science. But the astronomer of Dessau has taught us that there are still mines rich in ore, though they lie deep buried, and must be worked with more assiduity and with more care. I can conceive few more unpromising subjects from which to extract a definite result than were the solar spots when Schwabe first attacked them."

In 1862 Dr. Lee, in an able exposition of the many good works of Mr. Warren De la Rue, devotes about a page to "a department in celestial photography where Mr. De la Rue stands almost alone," that of *Heliography*. Although one or two isolated photographs of the Sun had been obtained previously, no uniformly successful method had been devised until Mr. De la Rue took up the problem. By applying the stereoscope to the pictures taken he showed that the faculæ were elevated above the photosphere, and he obtained traces of what were then called Nasmyth's willow leaves. His instrument, the Kew photoheliograph, is so familiar to us that I need not dwell on its work,

but the following passage from Dr. Lee's address is of interest to us to-day :

"I cannot refrain from expressing my belief that the success already achieved by our friend warrants us in entertaining the hope that before long he will be able, with the aid of stereoscopic pictures, to exhibit to us the rose-coloured prominences depicted on the sensitive plates as plainly as the faculæ have already been photographed."

Considering the date (1862) this is a somewhat remarkable expression of opinion. It must refer to the photography of the prominences in full sunlight, for Mr. De la Rue had obtained pictures of them at a total eclipse two years before, and this fact is duly recorded in the address. And of course Dr. Lee can have had no notion at the time of the particular manner in which his prophecy would be fulfilled; he must have been speaking merely from a general but deep-rooted confidence in the steady advance of scientific discoveries and methods. The achievement was not to fall to the lot of Mr. De la Rue, nor was it accomplished in his lifetime; but within two years of his death not merely the prominences themselves but their *spectra* were photographed for the first time* in full sunlight by our medallist of to-day.

The thirty years intervening between this last event and Dr. Lee's utterance, though it is not marked by the award of any medal by this Society for solar physics, was still far from being a barren period. But it was a time of steady general work rather than of conspicuous individual achievement. The honours of the chief step in advance—the discovery that the prominences could be seen with the spectroscope in full daylight—were shared by at least three people, being predicted by one and realised independently by two others. It does not, however, concern us to-day to follow the history of this period. The work of our medallist is essentially more recent. It began, indeed, so early as 1889 with some experiments conducted at Harvard College Observatory on the photography of prominences with an improvised spectro-heliograph; but his most remarkable achievements are not yet many months old. It is at any rate only within the last few months that we have had the pleasure of seeing on the screen the beautiful pictures which open up a new and vast field of research on the Sun.

We must, however, by no means neglect the early work which laid the sure foundations for these later triumphs. The experiments of 1889, though not very successful in themselves, contained the germs of the spectro-heliograph, and therefore of all the recent successes. In such a brief historical review, however, as can be attempted within the limits of this address we may begin with the year 1891, when the prominence spectrum was first photographed without an eclipse, as above mentioned.

* *Astronomy and Astrophysics*, vol. xi. (1892), p. 51.

The announcement of success was made to the British Association at the Cardiff meeting; and the paper is reproduced in the first number of the new journal *Astronomy and Astrophysics*, afterwards the *Astrophysical Journal*, which the energy of Professor Hale has done so much to found and maintain at its high level of excellence. Alongside the paper are placed two others by Professor C. A. Young and M. H. Deslandres, both containing similar announcements of success in photographing the spectrum of the chromosphere during the year 1891. Professor Hale's priority was of a few weeks only; and we may note with satisfaction the increased interest in solar physics which this threefold achievement implies. But he had already made a new departure by which he established a clear lead. In 1892 April he announced the successful completion of the spectro-heliograph, which represented, in his own words at the time, "a method by which photographs are now made of all the prominences visible round the entire circumference of the Sun with a single exposure, and by which faculæ are clearly shown even in the brightest portions of the Sun's disc." It is the latter part of this sentence to which I would call special attention. In the photography of the spectra of the prominences Professor Hale was one of several workers who reached results about the same time; but he was the first to realise that the faculæ could be photographed all over the Sun's disc, and thereby he curiously inverted the expectations of Dr. Lee. His special achievement was not only "to exhibit to us the rose-coloured prominences . . . as plainly as the faculæ," but to photograph the faculæ as plainly as the prominences; and in this achievement of 1892 the key note is struck of the theme which he has recently developed so magnificently.

The early history of a new idea is of such great interest that I will reproduce here verbatim Professor Hale's own account * of the manner in which he was led to his discovery.

"In his *Catalogue of the Bright Lines in the Spectrum of the Chromosphere*, published in 1872, Professor Young remarks as follows in regard to the H and K lines: 'They were also found to be regularly reversed upon the body of the Sun itself, *in the penumbra and immediate neighbourhood of every important spot*.' The observations referred to were made under the exceptional atmospheric advantages enjoyed at the summit of Mount Sherman, but even with the less favourable conditions common at the sea-level the same observer has repeatedly made out similar reversals in many spots. I do not know that these observations were confirmed elsewhere until the photographs made at this (Kenwood) Observatory in 1891 April brought out the same thing with great clearness. A few months later Professor Young secured at Princeton some photographs of the reversals, but my own attention has until recently been so fully

* *Astronomy and Astrophysics*, vol. xi. (1892), p. 413.

occupied with work on the prominences that I have had but little opportunity to go on with my proposed photographic study of spot spectra. Late in December, however, I secured some photographs of the spectrum of a spot in which the lines were so sharply defined that they were given a very careful examination. Not only were the bright lines at H and K more prominent in the penumbra than in the umbra of the spot, but their extent in the surrounding region was so great as to arouse the suspicion that similar reversals might be found on the disc, at points remote from the spot regions. To test this idea a series of six photographs of the spectrum was taken, the slit in each case being placed parallel to the position it had occupied in the exposure just preceding, and about 3′ distant from it. My expectations were not only realised by these photographs but greatly surpassed. In each of the six positions of a slit not more than 0·002 inch wide the K line was reversed in from 3 to 10 places. H was, without doubt, similarly affected in all of these points, but in some cases it was too faint to be certainly seen. Most, if not all, of these reversals were double, *i.e.* a dark line ran through the centre of the bright line, as is frequently observed in the spectrum of the electric arc. I have since suspected in several cases a strengthening of the broad dark absorption bands of the solar spectrum for a short distance on both sides of the bright reversals.

"Having thus found the surface of the Sun to be dotted over with regions in which the H and K lines are bright, I at once concluded that the *forms* of the reversed regions might be photographed with the spectro-heliograph in exactly the same way that prominences around the circumference are obtained. The first attempt to do this was made on January 12, when the adjustments of the instrument were incomplete, and connection had not been established between the accumulator and the clepsydra. In lack of more suitable motive power the slits were moved by hand, and even in this way bright forms near a spot group were shown on the photograph, though they could not be seen with the helioscope. The completion of the apparatus a few days later enabled me to secure very good photographs of the bright regions, and on comparing them with drawings and photographs taken in the ordinary way of faculæ near the limb it was found that the forms were identical."

It is almost needless at this date to describe the now well-known principle of the spectro-heliograph, but Professor Hale has himself given such a concise and simple statement of it recently that I cannot forbear quoting his words. "Imagine a direct-vision spectroscope," he says, "in which the eyepiece ordinarily employed is replaced by a (second) slit. If an image of the Sun is formed on the first slit of this spectroscope the second slit will permit the passage of only a narrow region of the spectrum corresponding in width to this slit. If the slit is now moved until it coincides with the Hβ line, for example, only hydrogen

light will pass through the instrument. If, then, a photographic plate is placed behind and almost in contact with the second slit, and the spectroscope is moved at right angles to the optical axis, an image of the Sun, in monochromatic hydrogen light, will be built up on the plate from the successive images of the slit. If the exposure is suitable the chromosphere and prominences will be shown surrounding this image."

It should be added that, though this principle suggested itself independently to our medallist in 1889, he subsequently learnt, and at once acknowledged, with that cordial appreciation of the work of others which he manifests unfailingly in his scientific writings, that it was not new, but had been stated essentially by Janssen as early as 1869, while instruments had been designed, and even constructed, by Braun and Lohse, in 1872 and 1880 respectively. But their experiments were unsuccessful, as indeed were the early experiments of Professor Hale himself. He was, however, the first to make a *successful* instrument and obtain results with it in the Kenwood Observatory.

It was completed early in 1892 and set to vigorous, regular, and successful work. Photographs of both prominences and faculæ were taken daily, and the importance of this new method of watching the Sun's activity was soon demonstrated, for in July the connection of a violent magnetic storm with faculous changes was clearly illustrated from the Kenwood photographs.* But before the end of the year which had seen its birth the doom of the Kenwood instrument was sealed. In the last number of *Astronomy and Astrophysics* for 1892 occurs a note about the 40-inch telescope of the Yerkes Observatory, stating that the large discs of optical glass made by Mantois for the University of Southern California had been purchased for the University of Chicago, and that Mr. Alvan Clark had contracted to grind the objective within eighteen months; that the site of the observatory was still undecided, but would probably be several miles outside the city. We know enough to recognise a rare piece of self-denial on the part of Professor Hale. We know that this great project, now carried to so successful an issue, originated in a visit paid by him and President Harper to Mr. Yerkes, a Chicago millionaire; and we know that Professor Hale must have foreseen the possibility, soon to become stern reality, that on him would fall the main work of founding a great observatory, which would necessitate the neglect or temporary abandonment of the infant spectro-heliograph which had just been born to him with such promise; and we know that he never flinched for a moment in the choice between his own personal work, sure and important

* Professor Hale's recent work, showing the astonishingly different results which may be obtained by setting the slit on a slightly different position of the broad K line, have given a new importance to questions of adjustment. Seeing that the spectro-heliograph was dismounted during July, it is just possible that some of the conclusions from these early records may need modification.

though it was, and the laborious and hazardous enterprise which might, if successfully piloted, make it possible for others to do great work. We know too with what rare skill and devotion he did pilot this enterprise, so that the Yerkes Observatory, the very site of which had not been determined a dozen years ago, now ranks not merely in magnificence of equipment, but in solid and brilliant work done, among the foremost in the world. We are content that our medallists should do one thing well, though it often happens by good fortune that we can find more than one excellence to admire in them; but I venture to think that we have seldom had a better example of versatility than on the present occasion, when we find the same man initiating and conducting a new and important journal, initiating and establishing one of the foremost observatories, inventing a new instrument which has an obviously great future before it, and recently finding an entirely new field of research for that instrument.

To attempt to follow the activities of such a man during a dozen years in the space allotted to this address would be merely bewildering; to touch on a few of the salient points is all that is possible. I will ask you to pass rapidly over the events of about ten years during which the Yerkes Observatory was being built and equipped. During the first three or four the spectro-heliograph was in regular use on every clear day at the Kenwood Observatory, and a series of valuable records was thus obtained, which is still in existence and of which we hope to hear more. But in 1895 May this series was interrupted by the dismounting of the instrument for removal to the new Yerkes Observatory, where it was hoped soon to remount it. Unfortunately there came a series of unexpected delays. The 12-inch telescope was wanted for other purposes, and to use a spectro-heliograph on the 40-inch telescope meant making a new instrument, for which funds were at first not forthcoming at all, and then came but slowly. There were difficulties in finding suitable lenses; and, worst of all, an accidental fire destroyed a nearly completed instrument. Looking back on the enterprises in hand during these years, our surprise must, however, be not that such delays occurred, but that they were not more effective. Patiently and resolutely each difficulty was met and conquered, and within four years (in 1899) the new and improved spectro-heliograph was ready for trial; within four more it was successfully at work exploring an entirely new domain of solar physics. A full description of this beautiful instrument has just been published in the third volume of the "Yerkes Observatory Publications." "The design finally adopted was reached only after long and careful consideration of the special conditions of the problem," after numerous forms had been designed, and some of them actually tried. Professor Hale states clearly his opinion that "the ideal form of spectro-heliograph is that in which the instrument is moved as a whole, while the image of the Sun and the photographic plate are stationary." But this presupposes a fixed telescope with some form of heliostat. To

attempt it with a large equatorial would be to throw the telescope into vibration and render good images hopeless. The only feasible solution of the problem seemed to be to move the Sun's image across the first slit by a motion of the telescope, the photographic plate being moved sympathetically across the second slit: and accordingly the telescope is moved in declination by the slow-motion motor. As regards dimensions, the slits are eight inches long and properly curved: the collimator and camera lenses are $6\frac{1}{4}$-inch Voigtländer portrait lenses; and two prisms in conjunction with a mirror give a total deviation of 180°. These figures, however, though they suggest a fine instrument, give no idea of the care and trouble necessary to work it. The principle of the spectro-heliograph is exceedingly simple, but the working of the instrument is quite sufficiently complex. In the description of it Professor Hale gives, under the heading "Adjustments,"* a list of *thirteen* distinct operations to be carried out with great nicety before a satisfactory photograph can be taken. We can imagine a veteran transit-circle observer thanking Providence that he was not born in these days. An important feature in the design is the method of setting the second slit on any desired line in the spectrum; we may almost say on any desired *part* of any line, for it is by the partition of the broad K line into significant regions that Professor Hale has within the past year opened up a new field of research with this instrument, of which I proceed to speak. But I will first follow his example in uttering a word of caution against too literal an interpretation of what is only intended as a working hypothesis. "The hypothesis," he says,† "is used mainly as a guide to further research, for, while it seems to describe in a fairly satisfactory manner many of the phenomena photographed, it is, of course, open to modification or rejection in the light of future results."

With this caution in mind we remark in the first place that what are called the H and K lines in the solar spectrum are not narrow and simple lines, but wide and complex bands. Since a line may be widened by pressure of the vapour producing it, sources of light at different pressures will give bands of different widths; and if the results be superposed, then at the middle we shall get light from all the sources, though at the edges we shall only get that from the source where the pressure is greatest. If we put the slit of a spectro-heliograph on one of the edges we get light from this source of great pressure *only*. Now in looking at any point of the Sun's disc we get just this state of things: we receive light from the successive sections of his surroundings traversed by the rays; and the pressure, and therefore the width of the band, will be different for each section. By putting the slit of the spectro-heliograph on an edge of the wide H or K band, however, we exclude the light from all but the section at greatest pressure, and practically view this section only. We can cut it out of the

* *Yerkes Obs. Pub.* vol. iii. p. 12. † *Ibid.* p. 13.

Sun's atmosphere as cleanly as a biologist cuts out a section of a specimen for microscopic examination. But we cannot proceed, as he does, to cut other sections as cleanly; for by moving the slit within the edge of the H or K line we get light not from the section of next greatest pressure only, but from it and the last combined; and as we go further inwards the complexity increases. We must also remember, though the fact has been omitted in what precedes for the sake of simplicity, that the continuous spectrum is also superposed in all cases. But it is clear that by setting the slit to various positions on the broad band different results will be obtained, from which it is not hopeless, though it may be very difficult, to compile a complete account of the form of the calcium vapour at different levels in the Sun's surroundings.

One thing is to be specially noted. Professor Hale may be photographing faculæ, but he is certainly not photographing faculæ *alone.* A more general term is required for the whole class of phenomena to which faculæ are closely related; and Professor Hale has suggested the name *flocculi.* The phenomena vary not only with the setting of the slit in different parts of the H or K band, but with a change to the line of a different element. On changing, for instance, to a line of hydrogen the remarkable fact is disclosed that, whereas the calcium flocculi are bright, those of hydrogen are *dark*; and, following up this result, Professor Hale has since found that even calcium flocculi are sometimes dark. Indeed, new results are multiplying so fast that it is perhaps prudent not to attempt to summarise them here. A new degree of freedom has been imparted to solar research by the discovery of this method. The new development is still in its infancy; but we have already had some most beautiful illustrations of its practical working exhibited to us, and from these alone we may confidently predict a great and important future for the study of the "flocculi."

I am tempted by the new name to make one more reference to the events of forty years ago. It fell to my lot on succeeding to the Savilian Chair at Oxford to collect for publication the astronomical correspondence of my predecessor, the Rev. Charles Pritchard. Among the letters were a number dealing with Nasmyth's discovery of "willow leaves" in the surface of the Sun, which created great excitement at the time, and led to a voluminous literature, now practically obsolete. A few of the letters were selected for publication,* and from the first of them it appears that the earliest confirmation of Nasmyth's views originated in an observation made by De la Rue in Pritchard's observatory at Freshwater; and Pritchard attributed the detection of the "willow leaves" to the use of the new solar eyepiece, suggested by Sir John Herschel, to whom he was writing. An

* *Memoirs of Professor Pritchard* (London: Seeley & Co., 1897), p. 240.

eyepiece with one reflection from a piece of plate-glass and a neutral-tinted shade was the most elaborate addition made to the telescope for solar work in those days. The second letter, to the same person, opens with the following words, which recurred to my mind on hearing Professor Hale's new name for solar phenomena :

"We had a strong debate on 'willow leaves' last Friday evening. Mr. Dawes will have it that he sees nothing but a 'flocculent precipitate.' Our 'willow leaves' are a sort of 'crystalline precipitate.'"

The date of this letter is 1863 December 15. May we hope that the shade of that highly strung, keen-eyed observer, W. R. Dawes, will rest the more peacefully now that, just forty years after he did battle for the flocculent precipitate,* the term flocculi is re-introduced into solar physics by so competent an authority as our medallist of to-day ?

I have already disclaimed any intention of giving a complete account of Professor Hale's work ; but there are at least two important researches, independent of his work with the spectroheliograph, which must be mentioned.

The first is his determined search for some method of observing the corona without an eclipse. Hitherto it has been unsuccessful, but that is owing to the difficulty of the problem, and not to any lack of skill or assiduity in the attack. A special expedition was made to Mount Etna in 1894 to try one of the experiments, and Professor Hale, after erecting the instrument and making the early observations himself, left the work for further trial in the able hands of Professor Riccò, who, however, had no better success. Several distinct methods have been tried at different times, utilising both the ultra-violet end of the spectrum and the heat radiation, the suggestion for exploring the corona with the bolometer being particularly happy, as it depends on a differential observation which ought theoretically to eliminate the sky glare ; but even this ingenious attack has been hitherto fruitless, for the coronal heat radiation, as has been shown from experiments made by Langley at a total eclipse, is extremely small compared with its light radiation.

Secondly, I must make a brief reference to the work done at the Yerkes Observatory from 1898 onwards in photographing the spectra of the fourth-type stars and measuring the photographs. The results of this laborious and thorough investigation have just appeared as one of the Decennial Publications of the University of Chicago. It contains 135 quarto pages of closely printed text and tables, and eleven beautiful plates. Forty-three photographs of the spectra of eight stars were selected for measurement, preference being given to well-established results

* See also *Mon. Not.* xxix. p. 119, line 36, where the word "flocculi" is actually used.

in a few cases. The stars being all faint, the research was a specially appropriate use of the great telescope; but at the same time the difficulties introduced precluded any very great accuracy being obtained, as is frankly announced in the volume. Nevertheless the results for motion in the line of sight show a precision which is by no means to be despised. An average of 15 lines for each star were compared with known positions for terrestrial elements, and velocities ranging from $+4km$ to $-28km$ per second were deduced. A corrected table of 537 lines in these spectra is then formed. Such figures may give some idea of the amount of work represented and the thoroughness with which it has been done. There follows a most able and interesting discussion of the physical character of these stars, summarised in fifteen conclusions, the last of which is that "fourth-type stars probably develop from stars like the Sun through loss of heat by radiation"; and though the other fourteen which lead up to it are full of interest I can here select one only for mention. Professor Hale finds a noticeable agreement of the fourth-type spectra with those of Sun-spots. In the region which is not masked by the carbon flutings the forty-six lines which are most strongly and frequently widened in the spots, as recorded in the *Greenwich Results* for 1880, are found to be the most prominent dark lines in the star. Hence it is suggested that spots similar to those on the Sun may possibly be numerous in fourth-type stars.

This result is in itself a justification of the twofold attack on the problem of the Sun, and carries us back to the proposition which I quoted at the outset—"It cannot be too often repeated that the Sun is the only star whose phenomena can be studied in detail." The reasons for studying Sun and stars side by side are obvious: and there is still a third line of research, necessary for properly conducting both the others, to be carried on in the laboratory. That Professor Hale is fully alive to this third necessity we have evidence in his exhaustive investigations of the fluting of magnesium in 1890: and in his work on the spark spectra of metals in liquids and under pressure, recently completed but awaiting funds for publication. It is perhaps noteworthy, and to many will come as a surprise, that one of the chief difficulties encountered by our medallist throughout has been lack of funds; for it is liable to be forgotten that other things are wanted besides a large telescope itself, and the funds for publication are the most likely to be forgotten of all. Several times the deficiencies have been supplied by the father of our medallist, the late William E. Hale; and later from a fund established in memory of him by his children, including of course our medallist himself.

I have indicated the great variety of Professor Hale's activities. It remains to be added that they are connected by a notable unity of purpose. Throughout this address I have quoted freely from his writings as the simplest and most efficient way of explaining the value of his work; and I will quote once

more, in order that this purpose may be declared in his own words. He is, of course, not speaking consciously about himself, but of the "aims of the Yerkes Observatory." In his address * at the Dedication, in 1897, he said—

"If I mistake not the signs of the times the Yerkes Observatory can render no better service to both astronomy and physics than to contribute, in such degree as its resources may allow, towards strengthening the goodwill and common interest which are ever tending to draw astronomers and physicists into closer touch. During its three years of publication the *Astrophysical Journal* has had the same end in view. The annual meetings of its editors, of late devoted mainly to the informal discussion of astrophysical investigations, have invariably been of great interest and value."

These are no empty sentiments; they are the words of a man who organised under the name of a meeting of editors the first gatherings of astrophysicists in a land where, owing to the wide separation of workers, scientific gatherings are far more difficult than for us; of a man who took special care that at the Yerkes Observatory physical laboratories should exist side by side with telescopes and spectroscopes; and especially of a man who could cheerfully lay aside his own fascinating work for the general good in founding a great observatory. We recognise in our medallist one who has more thought for others than for himself; and I am sure it would be his own wish that before concluding this address I should say one word in recognition of the efficient help which he has received from others, as it is only to be expected he would. To select any one name among many may be invidious, but that of Mr. Ferdinand Ellerman, who has been associated in all Professor Hale's work, experimental and otherwise, for the past thirteen years, and whose able assistance is often acknowledged by him with gratitude, is certainly worthy of mention to-day.

It is, of course, a disappointment to us that Professor Hale cannot be here in person to receive the medal, but we have knowledge which mitigates the disappointment. If our medallist had pleaded that the journey was too serious we, who so seldom venture to cross the Atlantic from this side, could scarcely have objected to the plea, though we might have urged that a visit to Europe had on at least one occasion proved apparently beneficial to him; for we remember with gratification that he returned from the meeting of the British Association in 1891 to originate the spectro-heliograph and the new journal of *Astronomy and Astrophysics*. But Professor Hale enters no plea of the kind. That he is not on our front bench, where we should have been so delighted to see him, to-day is due simply to the fact that he is filling a place of even greater honour: he is initiating a new work of science.

* *Astrophysical Journal*, vol. vi. (1897), p. 310

He was led to pay a visit to California, to study the conditions for solar work, and found them so admirable that he felt compelled to commence operations at once on such a modest scale as is possible with his present very limited resources. We shall earnestly hope that these will soon be supplemented in such a manner as to put the new enterprise on a proper basis. Those who have the administration of funds for scientific research doubtless find the choice between various admirable proposals no easy matter. Indeed, we hear of more than one new project in which Professor Hale himself is interested. We hear not only of a possible new solar observatory, but of a somewhat novel type of observatory in the southern hemisphere; and no one who knows anything of the recent history of astronomy can fail to recognise the pressing importance of both these needs. The southern hemisphere has been unduly neglected from the first, and the leeway to be made up in studying it becomes greater every year. If half a dozen new observatories instead of one were established in the southern hemisphere to-morrow it would take them many years to atone for past neglect.

But there are equally strong reasons, having their origin in undue neglect in the past, for the establishment of a new solar observatory, as I endeavoured to show in the early part of this address. If Schwabe "taught us that there are still mines rich in ore" by merely counting the Sun-spots, what vast new gold-fields has not Professor Hale prospected by showing that every spot, which to Schwabe was a mere unit, is a region which must be explored from hour to hour, from section to section, and from one chemical element to another! He has pointed out the defective state of our knowledge as clearly as Flamsteed did two centuries ago; and, when the obvious need of a fine steady climate for the work is added, he has made out just as good a case for the foundation of a solar observatory as did Flamsteed for the foundation of the Royal Observatory at Greenwich. And if by good fortune it should be founded and the query should again be put, "Who is to take charge of it?" let us hope that the answer will be, in the words of King Charles II., "Why, he who told us the need of it!"

But it is unprofitable to venture on the quicksands of anticipation when we can tread on the solid ground of accomplished fact. I have surely said enough, however imperfectly, to justify to you fully the award of the Council, and it remains only to hand to the American Ambassador for transmission to Professor Hale the outward and visible symbol of our esteem.

The President then, addressing the American Ambassador, said:

"Mr. Choate, it is but three years since your Excellency did us the honour to attend our Annual Meeting to receive the

medal on behalf of Professor Pickering. It is, in every way, a great pleasure to us to see you here again so soon.

"It will, I am sure, not lessen the value of this medal which we ask you to send to Professor Hale as a token of the high value we set upon his work if I add that it is also, in some sort, a symbol of our cordial admiration of the great advances made in our science by the astronomers of the United States and those citizens who have so generously aided them."